Content available at: https://www.ipinnovative.com/open-access-journals

Journal of Pharmaceutical and Biological Sciences

Journal homepage: https://www.jpbs.in/

Original Research Article

Design, development and characterization of ketorolac tromethamine-loaded transdermal patches

Rajandra Bajirao Dubal[1], **Jameel Ahmed S Mulla**[1]*, **Mukesh Vinod Kapse**[1]

[1]*Shree Santkrupa College of Pharmacy, Ghogaon, Maharashtra, India*

ARTICLE INFO

Article history:
Received 19-07-2024
Accepted 18-09-2024
Available online 09-01-2025

Keywords:
Ketorolac Tromethamine
Transdermal Patches
Design of Experiment
Solvent Casting Method
In Vitro Drug Release

ABSTRACT

Aim and Objective: The aim of this study was to develop and evaluate ketorolac tromethamine-loaded transdermal patch, designed for sustained drug release and enhanced patient compliance in pain management.

Introduction: Pain management is a critical component of healthcare, especially in conditions requiring long-term treatment. NSAID, such as ketorolac tromethamine, is commonly prescribed for the relief of moderate to severe pain due to their potent analgesic and anti-inflammatory properties. However, the conventional forms of ketorolac can be associated with limitations and the need for frequent dosing.

Materials and Methods: Different combinations of polymers (HPMC K100 and PVP K30) and plasticizer (PEG 400) were used to prepare the transdermal patches by solvent casting method. The drug was dissolved in polymeric solution. The solution was poured into mould and allowed to dry to form a patch. After preparation of Transdermal patch evaluation tests were performed.

Results: The transdermal patches exhibited good physical characteristics with uniform thickness and weight variation. The folding endurance test indicated high mechanical strength, with patches enduring multiple folds without breaking. The moisture content was within acceptable limits, ensuring patch stability. The drug content was shown higher value with minimum batch variability. The *in vitro* drug release study showed that patches containing lower concentrations of HPMC K100 and higher concentration PVP K30 had the highest drug release rates, with up to 90% of the drug released over 8 hours.

Conclusion: The ketorolac tromethamine-loaded transdermal patches developed in this study demonstrated promising characteristics for sustained drug delivery. Formulations F3 batch provided optimal drug release profiles. These patches could potentially improve patient compliance in pain management by providing a non-invasive, sustained-release drug delivery system.

1. Introduction

There has been a rise in interest in transdermal drug delivery systems (TDDS) and the administration of medications via the skin for both systemic and topical purposes, including topical delivery for the treatment of sick skin.[1] When it comes to a multitude of other drug administration routes, the skin offers several noteworthy advantages over others. These include the capacity to prevent issues with gastric irritation, pH, and emptying rate effects. To circumvent hepatic first-pass metabolism, which enhances the drug's bioavailability, to minimize the risk of systemic side effects by reducing plasma concentrations in comparison, to oral therapy and to offer a sustained release of the drug at the site of application, quick therapy termination by eliminating the device or formulation, Less variation in medication plasma levels and prevention of injection-related discomfort. Additionally, pulsed entrance into the

* *Corresponding author*.
E-mail address: jameelahmed5@gmail.com (J. Ahmed S Mulla).

https://doi.org/10.18231/j.jpbs.2024.021

systemic circulation, which frequently results in undesired side effects, can be eliminated via transdermal distribution.[2]

Ketorolac tromethamine is a potent nonsteroidal anti-inflammatory drug (NSAID) widely used for its analgesic properties, particularly in the management of moderate to severe pain. Despite its efficacy, the oral and parenteral administration of ketorolac is often associated with adverse gastrointestinal, renal, and cardiovascular effects, primarily due to its systemic exposure and first-pass metabolism.[3] Transdermal drug delivery systems (TDDS) offer a promising alternative by providing controlled and sustained drug release directly through the skin, thereby bypassing the gastrointestinal tract and avoiding first-pass hepatic metabolism.[4] This approach not only enhances patient compliance by reducing the frequency of dosing but also minimizes systemic side effects and improves therapeutic outcomes.[5]

The development of a transdermal patch for ketorolac aims to exploit these advantages, providing continuous pain relief with a more favourable safety profile. The formulation of such a patch involves the careful selection of polymers, plasticizers, and penetration enhancers to ensure adequate drug release and skin permeability.[6] Furthermore, comprehensive evaluation of the patch's physicochemical properties, mechanical strength, adhesion capabilities, and *In vitro* drug release profiles is essential to ensure its efficacy and safety.[7,8] It is crucial to reduce the occurrence of adverse effects (ulcer in stomach) of ketorolac tromethamine while preserving the anti-inflammatory and analgesic efficacy when formulated as Transdermal patch. This research article focuses on the formulation and evaluation of a ketorolac transdermal patch, highlighting its potential to revolutionize pain management practices by offering a novel, non-invasive, and patient-friendly therapeutic option.

2. Materials and Methods

2.1. Materials

Ketorolac tromethamine was purchased from Dhamtek pharma, Mumbai. HPMC K100 and Dimethyl Sulfoxide (DMSO) obtain from Research Lab Fine Chem, Mumbai. Polyvinyl pyrrolidone (PVP K30), Methanol and PEG 400 (Polyethylene glycol 400) were obtained from Loba Chemise Pvt. Ltd, Mumbai.

2.2. Factorial design

Using Design-expert software, a three-level factorial design was developed. This meant that every conceivable combination of the three levels of each component under consideration had to be tested in the experiment. The amounts of HPMC K100 (X_1) and PVP K30 (X_2) were the independent variables that were employed (Table 1). A multilevel factorial design (3^2) was used to screen the independent variables, and nine different formulations of Ketorolac Tromethamine Transdermal Patch were developed. The optimal formulation was identified by evaluating in vitro drug release studies (Y_1) after all formulations were created using Solvent casting method.[9]

Table 1: Independent variables

Coded value level	Independent variables	
	X1 HPMC K100 (mg)	X2 PVP K30 (mg)
-1	150	150
0	200	200
+1	250	250

2.3. Preparation of transdermal patch

Ketorolac tromethamine-loaded matrix-type transdermal patches were prepared by using solvent casting method. Dissolve the required quantities of polymers (HPMC K100 and PVP K30) in water and methanol (1:5). Stir the solution until the polymer is completely dissolved.[9] Accurately weigh the required amount of ketorolac tromethamine (10mg/4cm^2) and dissolve in the polymer solution. Add the plasticizer (PEG 400) and permeation enhancer (DMSO) to the solution (Table 2). Mix thoroughly to ensure uniform distribution of the Ketorolac Tromethamine and other components. Pour the prepared solution into a suitable casting mold.[10] Spread the solution evenly to form a uniform patch. Allow the solvent to evaporate at room temperature or in a drying chamber/oven at a controlled temperature. Ensure the patch is dried completely to form a solid patch. Once dried, carefully remove the patch from the mold and cut the patch into 4 cm^2 size using a sharp blade or cutting tool.[11]

Table 2: Formulation of ketorolac tromethamine transdermal patch

Ingredients	F1	F2	F3	F4	F5	F6	F7	F8	F9
Ketorolac tromethamine (mg)	150	150	150	150	150	150	150	150	150
HPMC K100 (mg)	150	150	150	200	200	200	250	250	250
PVP K30 (mg)	150	200	250	150	200	250	150	200	250
PEG 400 (%W/W)	30	30	30	30	30	30	30	30	30
DMSO (%W/W)	2	2	2	2	2	2	2	2	2
Water: Methanol	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5

2.4. Evaluations of transdermal patches

2.4.1. Weight variation

The weight variation test is a critical quality control parameter in the development of transdermal patches. It ensures uniformity in drug content and patch composition, which is essential for consistent drug delivery and therapeutic efficacy.[12] The study was carried out on three patches obtained from casting solution. The mean weight of the patch as well as the deviation from the mean was obtained and the data was recorded. The weight of each patch was taken using electronic balance. The test was done to check the uniformity of weight and thus check the batch-to- batch variation.[13]

2.4.2. Thickness

The thickness of a transdermal patch is a crucial parameter that influences drug release rates, adhesive properties, and overall performance of the patch. Consistency in thickness across patches ensures uniform drug delivery and therapeutic efficacy. Measurement of patch thickness is an essential quality control step in the development and production of transdermal drug delivery systems.[14] The thickness of the patch was assessed by using micrometer screw gauge at different points of the patch. From each formulation three randomly selected patches were used. The average value for the thickness of a single patch was determined.[15]

2.4.3. Folding endurance

The folding endurance test involves repeatedly folding a patch at the same location until it breaks or shows visible signs of damage. The number of folds a patch can endure before failure is recorded as its folding endurance.[16] Randomly select patches from the batch. Fold each patch at the same point (typically the center) repeatedly by hand. Count the number of folds until the patch shows visible signs of damage (cracking, breaking, or loss of flexibility). Record the number of folds for each patch.[17]

2.4.4. Percentage of moisture content

The moisture content can be measured using a gravimetric method, where patches are weighed before and after drying to a constant weight.[18] Randomly select patches from the batch. Weigh the patches individually to obtain the initial weight (W1). Dry the patches in an oven at a specified temperature (typically 60°C to 80°C) until a constant weight is achieved. Weigh the dried patches to obtain the final weight (W2). Calculate the percent moisture content using the formula.[19]

2.4.5. Determination of surface pH

The patches were allowed to swell by keeping them in contact with 1 ml of distilled water for 2 h at room temperature and pH was noted down by bringing the electrode in contact with the surface of the patch, allowing it to equilibrate for 1 min.[16]

2.4.6. Percent elongation

When stress is applied, a patch sample stretches and this was to as strain. Strain is basically the deformation of patch divided by original dimension of the sample. Generally, elongation of patch increases as the plasticizer content increases. It is calculated by using following formula.[7]

2.4.7. Drug content

The drug content of a transdermal patch is an essential evaluation to ensure uniformity and accuracy in drug dosage. Cut a specified area of the transdermal patch (1 cm^2) to ensure uniformity. Place the weighed patch in a volumetric flask containing 25 ml of phosphate buffer pH 7.4 was added gently heated to 45^oC for 15 minutes, and kept for 24 hours with continuous stirring on magnetic stirrer. Then, the volume was made up to 50 ml with phosphate buffer of pH 7.4. After that, allow the solution to settle, and filter it using filter paper to remove any insoluble components of the patch. Take the filtered solution and dilute it with the solvent to bring the drug concentration within the detection range of the spectrophotometer. Analyse the diluted sample using a UV-Visible spectrophotometer at 366 nm wavelength.[20]

2.4.8. In vitro release study

In vitro release studies were carried out using Franz diffusion call 10 ml capacity. Cellulose Acetate membrane was isolated and used for the study. Accurate size of patch was kept on the Cellulose Acetate membrane.[18] The Cellulose Acetate membrane was clamped between donor and receptor compartment. The receptor compartment was filled with 10 ml pH 7.4 Phosphate Buffer maintained at 37ºC and stirred by using magnetic stirrer. 1ml sample was collected at suitable time interval (i.e., for every 2 hrs. Until complete drug was released) and replaced with fresh buffer. The collected samples were analysed for drug content by UV visible Spectrophotometer at 366nm.[21]

3. Results

Ketorolac tromethamine loaded transdermal patches were prepared by solvent casting method using HPMC K100 and PVP K30 in different concentrations.

3.1. Factorial design

The results of Design of Experiment (DOE) were shown in (Table 3), (Figures 1 and 2). The variables being analyzed are the amounts of HPMC K100 (X_1) and PVP K30 (X_2) used in the formulation.

The ANOVA for Response Surface Quadratic model and Model summary statistics- influence of formulation

Table 3: Factors and response

Formulation Code	HPMC K100 (X1(mg)	PVP K30 (X2) (mg)	In vitro Drug Release (Y1)(%)
F1	150	150	83.2±1.3
F2	150	200	88.3±1.2
F3	150	250	90.7±1.1
F4	200	150	71.4±1.4
F5	200	200	77.2±1.4
F6	200	250	79.2±1.4
F7	250	150	60.7±1.5
F8	250	200	67.2±1.3
F9	250	250	70.1±1.3

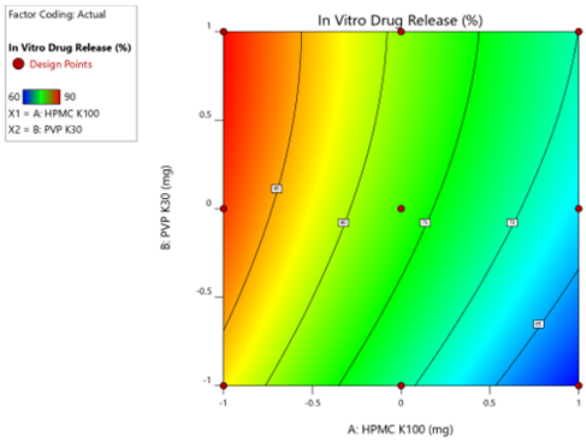

Figure 1: 2D Contour plots for evaluating influence of HPMC K100 (X1) and PVP K30 (X2) on In vitro DrugRelease (Y1)

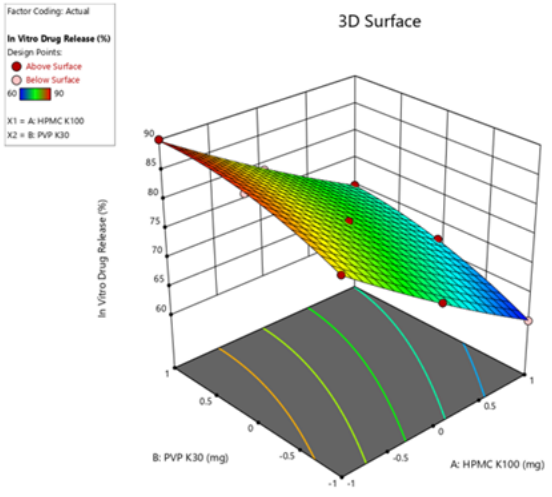

Figure 2: 3D Response surface plots for evaluating influence of HPMC K100 (X1) and PVP K30 (X2) on In vitro drug release (Y1)

variables on the response factors for Ketorolac Transdermal Patch were shown in (Table 4).

3.2. Anova for quadratic model

3.2.1. Response 1: In vitro drug release

Factor coding is Coded. Sum of squares is Type III – Partial. The Model F-value of 2458.37 implies the model is significant. P-values less than 0.0500 indicate model terms are significant. In this case X_1, X_2, X_1X_2, X_1^2, X_2^2 are significant model terms.

3.3. Evaluations of ketorolac tromethamine transdermal patch

Different evaluation parameters like weight variation, Thickness, Folding Endurance, Moisture Content, pH, Percent Elongation and Drug Content were tabulated in (Table 6).

3.3.1. Weight variation

The Average weight variation of transdermal patches from F1 to F9 was found in the range of 4.3±0.4 to 6.7±0.4.

3.3.2. Thickness

The thickness of transdermal patches from F1 to F9 was found in the range of 0.19 mm to 0.23 mm.

3.3.3. Folding endurance

The Folding Endurance of transdermal patches from F1 to F9 was found in the range of 139±3 to 169±3.

3.3.4. Moisture content

The Moisture Content was found to be very less in F2, F6 and F8 Formulation i.e.,4%, 5% and 4% respectively and F1, F3, F4, F5, F7 and F9 formulation contain 11%, 10%, 8%, 10%, 9% and 9% moisture respectively.

3.3.5. pH determination

The pH of transdermal formulations was found in the range of pH 5.8 to 6.2 which indicates skin capability.

3.3.6. Percent elongation

The Percent Elongation of transdermal patches was found in the range of 56±2.1 to 89±3.1.

3.3.7. Drug content

The drug content analyses of the prepared formulations have shown that the process employed to prepare the patches was capable of giving uniform drug content, with minimum batch variability. The drug content was found between 84.3±0.02% to 95.2±0.03%.

Table 4: ANOVA for response surface quadratic model

ANOVA for response surface quadratic model for ketorolac transdermal patch				
Response Factor	**Model F-Value**	**P -Value**	**Lack of fit Mean**	**C.V. %**
In vitro Drug Release	2458.37	< 0.0001	76.11	0.3345

In Vitro drug release (Y1) = $76.89-10.67X_1+4.17X_2+0.7500X_1X_2+0.6667X_1^2-1.83X_2^2$ Eq (1)

Table 5: Model summary statistics- influence of formulationvariables on the response factors for ketorolac transdermal patch

Model summary statistics- influence of formulation variables on the response factors for Ketorolac Transdermal Patch						
Response Factor	**Source**	**Standard Deviation**	**R2**	**Adjusted R2**	**Predicted R2**	**Adequacy Precision**
In vitro Drug Release	Quadratic	0.2546	0.9998	0.9993	0.9972	142.7175

Table 6: Evaluations of ketorolac tromethamine-loadedtransdermal patches

Characteristics	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Weight Variation (%)*	5.2±0.5	6.7±0.4	5.6±0.6	6.5±0.5	5.5±0.8	4.8±0.5	6.2±0.6	4.3±0.4	5.8±0.5
Thickness (mm)	0.22	0.21	0.19	0.19	0.20	0.22	0.21	0.22	0.23
Folding Endurance*	162±6	157±2	163±3	140±2	169±3	155±4	164±7	139±3	148±5
Moisture content (%)	11	4	10	8	8	5	9	4	9
pH	6.2	5.9	5.8	6.1	5.9	6.2	5.8	6.0	5.9
Percent Elongation*	59±1.2	89±1.1	58±3.2	56±2.1	68±3.2	71±2	69±2.1	84±2.2	70±3.1
Drug content (%)*	87.2±0.02	91.4±0.04	95.2±0.03	86.1±0.03	90.2±0.06	92.3±0.04	84.3±0.02	86.5±0.05	89.1±0.01

*All values are mean ± SD, n = 3

3.3.8. In vitro drug release

The *in vitro* drug release of Ketorolac tromethamine loaded transdermal patch was performed by Franz diffusion cell by using cellulose acetate membrane. F1- F9 shows the drug release of 83.2±1.3, 88.3±1.2, 90.7±1.1, 71.4±1.4, 77.2±1.4, 79.2±1.4, 60.7±1.5, 67.2±1.3, 70.1±1.3 respectively as shown in (Table 7) & (Figure 3).

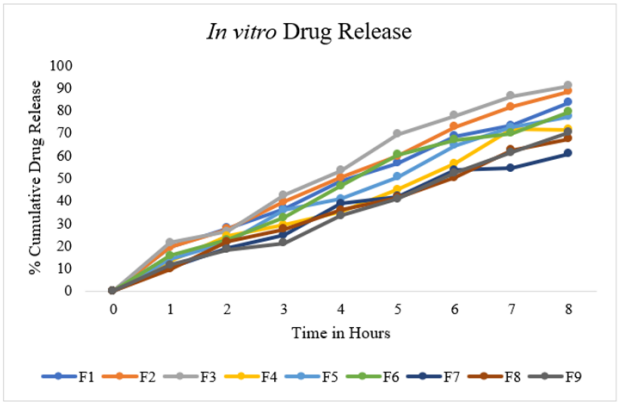

Figure 3: Percent cumulative drug release

4. Discussion

The DOE results indicate that the optimal formulation for maximum drug release involves lower concentrations of HPMC K100 and higher concentration PVP K30. This information is crucial for formulating an effective transdermal patch with the desired drug release profile. The Predicted R^2 of 0.9972 is in reasonable agreement with the Adjusted R^2 of 0.9993; i.e. the difference is less than 0.2. Adeq Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. Here ratio of 142.718 indicates an adequate signal. This model can be used to navigate the design space (Table 5). The mathematical modelling of prepared transdermal patch was carried out and following equations were obtained.

Lower weight variation indicates better uniformity in the amount of drug and excipients distributed across the patch. Patches with higher weight variation might need process optimization to ensure uniformity, which is crucial for consistent drug release and efficacy.

Consistent thickness is important for uniform drug release. The slight variations suggest good control during manufacturing, ensuring that the patches have consistent physical dimensions, which is essential for predictable performance.

Higher folding endurance values (e.g., 169 ± 3) suggest that the patches are more flexible and less prone to cracking or breaking when applied to the skin. Lower values may indicate brittleness, which could lead to patch failure during use. Patches with higher folding endurance are generally preferred for their robustness during handling and application.

Table 7: Percentage cumulative drug release

Time(Hrs)	1	2	3	4	5	6	7	8
F1	19.4±1.3	27.7±1.3	36.4±1.1	48.5±1.3	56.5±1.3	68.4±1.4	73.2±1.4	83.2±1.3
F2	19.2±1.2	27.4±1.4	39.5±1.3	50.2±1.2	59.7±1.4	72.6±1.2	81.4±1.2	88.3±1.2
F3	21.4±1.1	26.3±1.5	42.4±1.6	53.2±1.5	69.3±1.0	77.5±1.1	86.2±1.3	90.7±1.1
F4	13.2±1.6	24.3±1.1	29.2±1.7	35.1±1.2	44.8±1.1	56.3±1.2	71.5±1.2	71.4±1.4
F5	14.04±1.1	21.5±1.2	35.7±1.2	40.6±1.1	50.4±1.2	64.3±1.3	72.4±1.1	77.2±1.4
F6	15.6±1.3	22.6±1.2	32.4±1.1	46.5±1.0	60.2±1.2	66.8±0.7	69.7±1.1	79.2±1.4
F7	10.4±1.5	18.8±1.5	24.6±1.3	38.6±0.8	41.8±1.5	53.5±1.9	54.3±1.6	60.7±1.5
F8	9.5±1.2	21.8±1.2	27.2±1.4	35.7±1.2	41.4±1.4	50.2±1.7	62.4±1.0	67.2±1.3
F9	11.4±1.0	18.3±0.9	21.1±1.1	33.2±1.4	40.6±1.2	52.3±1.4	61.3±1.2	70.1±1.3

Moisture content influences the stability and adhesion of the patch. Lower moisture content (e.g., 4%) suggests better stability, reducing the risk of microbial growth or degradation of the patch materials. Higher moisture content (e.g., 11%) could affect the patch's mechanical properties and shelf life, potentially requiring moisture-resistant packaging.

The pH values are slightly acidic, which is generally suitable for skin application. This range is close to the skin's natural pH, minimizing the risk of irritation or discomfort. Consistent pH values across formulations indicate stable chemical properties and compatibility with the skin.

Percent elongation of F2 and F8 formulation was found to be good, which indicates good tensile strength. Percent elongation is an indicator of the patch's flexibility and ability to stretch without breaking. Higher values (e.g., 89% ± 1.1) indicate that the patch can stretch significantly, which is beneficial for patches applied to areas of the body that move frequently. Lower values suggest that the patch may be less flexible and more prone to breaking or losing adhesion.

Batch F3 has the highest drug content (95.2±0.03%), suggesting it is the most efficient in incorporating the drug, possibly due to better uniformity in preparation and mixing. F7 has the lowest drug content (84.3±0.02%), which might indicate some loss of drug during the formulation process, or possibly insufficient drug dispersion. Formulations F2, F3, F5, and F6 exhibit higher drug content (above 90%). These batches are promising candidates for further development as they show better drug incorporation and minimal loss during preparation.

Formulation F3 shows maximum drug release i.e. 90.7±1.1 % of drug at 8 hrs. The maximum drug release of F3 formulation indicates that lower concentration of HPMC K100 and higher concentration of PVP K30 influences the release of drug.

5. Conclusion

In this research, we successfully formulated and evaluated ketorolac tromethamine-loaded transdermal patches, aiming to provide a controlled and sustained release of the drug for effective pain management. The transdermal patches were prepared using different polymers and evaluated for various physicochemical properties, including thickness, weight variation, folding endurance and moisture content. The results demonstrated that the formulated patches exhibited acceptable physicochemical properties with uniform thickness in the range from 0.19 mm to 0.23 mm, minimal weight variation i.e. 4.3±0.4 to 6.7±0.4 %, high folding endurance which found in a range 139±3 to 169±3, appropriate moisture content which was 4 to 11 %, pH was found between 5.8 to 6.2 and % elongation found between 56±2.1 to 89±1.1. The drug content of a transdermal patch is an essential evaluation to ensure uniformity and accuracy. The drug content of all formulations was obtained in range from 84.3 ± 0.02 and 95.2 ± 0.03 %.The drug release studies indicated a sustained release profile, which is desirable for maintaining therapeutic drug levels over an extended period. Out of all formulation F3 batch shows maximum drug release i.e. 90.7±1.1 % of drug at 8 Hours. Moreover, the transdermal patches showed good mechanical properties, flexibility, and stability, which are crucial for ensuring their durability and performance during application. The incorporation of suitable permeation enhancers significantly improved the drug permeation rate, highlighting the potential of these formulations for clinical use.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Mulla J, Pujari P, Sangar O. An Overview of the Transdermal Drug Delivery System. *Int J Creative Res Thoughts*. 2022;10(5):497–507.
2. Balaji P, Thirumal M, Gowri R, Divya V, Ramaswamy V. Design and evaluation of matrix type of transdermal patches of methotrexate. *International Journal of Pharmaceutical, Chemical and Biological Sciences*. 2012;2:464–71.
3. Verma PR, Lyer S. Transdermal delivery of propranolol using mixed grades of Eudragit: design and In vitro and in vivo evaluation. *Drug Dev Indus Pharm*. 2000;26(4):471–6.

4. Bhatt P, Gnanarajan G, Velmurugan S. Formulation and evaluation of ketorolac tromethamine-loaded transdermal films. *J Pharm Sci Res*. 2012;4(9):1915–23.
5. Jain NK, Naruka PS. Formulation and evaluation of transdermal drug delivery system of ketorolac tromethamine. *Asian J Pharm Sci*. 2009;4(1):97–101.
6. Naik PD, Patel S, Parma D. Preparation and evaluation of transdermal drug delivery system of ketorolac tromethamine. *Int J Pharm Sci Rev Res*. 2009;1(1):10–4.
7. Kumar R, Philip A, Pathak K. Modified transdermal technologies: breaking the barriers of drug permeation via the skin. *Trop J Pharm Res*. 2007;6(1):633–44.
8. Prausnitz MR, Langer R. Transdermal drug delivery. *Nature Biotech*. 2008;26(11):1261–8.
9. Shahidulla FZ. Formulation, optimization and evaluation of hexadecanoic acid phytosomal gel for anti-fungal activity. *Int J Pharm Sci Res*. 2023;14(1):519–29.
10. Jadhav V, Jamakandi V, Mulla J, Borkar S, Karpe P, Suresh RE. Reservoir Type Nicorandil Transdermal Delivery System by Using Permeation Enhancers. *Indian Drugs*. 2009;46(9):23–31.
11. Patel PS, Patel C. Formulation and evaluation of transdermal patch of repaglinide. *Int Schol Res Nnetwork Pharm*. 2011;3(1):166–21.
12. Chauhan I, Bajpai M. Formulation and evaluation of transdermal drug delivery of raloxifene hydrochloride. *Int J Pharm Sci Res*. 2010;1(12):72–9.
13. Sibaji A, Biplab K. A novel technique for treating the type ll diabetes by transdermal patches prepared by using multiple polymer complexes. *Int J Pharm Res Dev*. 2010;9:195–204.
14. Popovich AL, Ansel N. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. vol. 6. and others, editor. Lippincott Williams & Wilkins; 2013. p. 21–30.
15. Verma P, Iyer S. Transdermal delivery of propranolol using mixed grades of Eudragit: design and In vitro and in vivo evaluation. *Drug Dev Indus Pharm*. 2000;26(4):471–6.
16. Gannu R, Yamsani V, Palem C, Yamsani M. Enhanced bioavailability of lacidipine via microemulsion-based transdermal gels: formulation optimization, ex vivo and in vivo characterization. *Int J Pharm*. 2008;383(2):173–82.
17. Desai P, Shah P, Chauhan B. Development and evaluation of antiaging transdermal delivery system for resveratrol. *Pharm Dev Technol*. 2010;15(2):156–64.
18. Taware A, Thorat S, Waikar D, Wayal S. Formulation and Evaluation of Transdermal Patch. *Int J Pharm Res Appl*. 2023;8(3):2454–64.
19. Patel D, Patel DNS, Parmar M. Preparation and evaluation of transdermal drug delivery system of ketorolac tromethamine. *Int J Pharm Sci Rev Res*. 2009;1(1):10–4.
20. Jamakandi V, Mulla J, Vinay B. Formulation, characterization and evaluation of matrix type trandermal patches of model antihypertensive drug. *Asian J Pharm*. 2009;3:59–65.
21. Soud A, Panchagnub R. Role of dissolution studies in controlled release drug delivery system. *STP Pharm Sci*. 1999;9:157–68.

Author's biography

Rajandra Bajirao Dubal, Research Student https://orcid.org/0009-0006-4658-8403

Jameel Ahmed S Mulla, Professor https://orcid.org/0000-0002-1042-7134

Mukesh Vinod Kapse, Research Scholar https://orcid.org/0009-0002-3960-6934

Cite this article: Dubal RB, Ahmed S Mulla J, Kapse MV. Design, development and characterization of ketorolac tromethamine-loaded transdermal patches. *J Pharm Biol Sci* 2024;12(2):144-150.